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Research and scientific activity - Canadian federal expenditures,1938-1946.

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INTRODUCTION

Research and scientific activity have for long been recognized as prerequisites for any society that wished to improve its knowledge. Standards of health, and of industrial performance in all fields are known to be greatly dependent on these fields of endeavour. The war, however, acted as a forcing ground for the development of research activity, and focussed attention on two aspects. It revealed the enormous achievement derivable from increased national efforts on research, and secondly it proved how the careful integration of research planning could open new horizons and extend the whole achievement. The lesson from this war experience is that the national budget on research—the size of the expenditures and the direction of these into the required fields—is closely associated with the present and the future levels of employment and income.

This report outlines a framework that can be used to provide public information on the size and nature of Canada's research expenditures. The information in this report is confined to the type of research and scientific work done by Federal Government departments. It should be followed by surveys of the research being currently undertaken by Provincial governments, by semi-public agencies, like universities and hospitals, and by industry. When all such information has been obtained, a simple summary report outlining the nation's total research budget can be made available. This type of information should permit increased public discussion of the total research program in Canada, of its adequacies or inadequacies in amount, and of its directions and ends. Such information also should allow comparisons to be made between Canada's research efforts and those in other countries, comparisons of total research as well as those in specific research fields. It may aid also in increasing the co-ordination of the research being undertaken or planned by government agencies, by semi-public bodies and by industry.

The present report is divided into three sections. The first deals with the concept, economic significance, definition and measurement of research and scientific activity. Since there is no generally accepted definition of what part of human effort is covered by the terms "research", "development", and "scientific activity", it was considered essential for a proper understanding of the quantitative measurements provided in this report to state specifically what was meant by research and related activities and how important they were for human advancement. The second section provides a factual summary dealing with the expansion of the various types of research activity by Federal Government departments, its role in the economy, and employment and income of research personnel in the service of the Dominion Government. Supplementary statistical material dealing with some detailed aspects of the survey is shown in Section III. An Appendix briefly describing research and scientific activity currently undertaken by the Dominion Government completes the report.

The survey of Dominion Government expenditures on research and other scientific work brings out three main points:

1. Expenditures for research and development work undertaken by Federal Government departments have been increased by about six times during 1938-46.

2. In spite of the substantial expansion of scientific work and the fact that the Federal activity comprises a large part of research and development work done in Canada, the amounts involved are relatively small:

   (a) Compared with total Federal Government outlay, expenditures for research and development amounted to 1 per cent in 1945, as against 2 per cent in 1938.

(b) Compared with the value of output in primary industries (agriculture, fisheries, mining and forestry), Federal research expenditures devoted to the development and conservation of such resources amounted to only 0.22 per cent of net value of production in 1945.

3. A large portion of research expenditures goes into capital and operating costs and only a smaller portion into salaries and wages of research personnel. Earnings of research personnel are higher than those of the average civil servant.

   (a) In 1946 about $12.2 million, or one-third of total expenditures for scientific activities amounting to $33.9 million, went into salary and wage payments, with the remainder being spent for capital items, e.g. structures and equipment and operating expenses (excluding salaries and wages).

   (b) Average earnings of research personnel engaged in research and other types of scientific activity were $2,054 in 1946. Average salaries of professional persons amounted to $2,740 for the year, while non-professional staff, mainly clerical personnel, workmen and students, earned an estimated $1,601.

   (c) Earnings of research personnel in 1946 are, on an average, some 5 per cent higher than in 1945 and 10 per cent for certain groups.

   (d) In 1945, research personnel both professional and non-professional earned on an average about $2,000 as compared with approximately $1,600 for the average Civil Servant.

Mr. B. P. Scull, Associate Director-General of the Research and Development Branch of this Department, rendered valuable assistance in the conduct of the survey on which this report is based. The report was prepared by Dr. O. J. Firestone, Director of the Economic Research Branch, assisted by Miss R. E. Addison.

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SECTION I. CONCEPT, ECONOMIC SIGNIFICANCE AND MEASUREMENT OF RESEARCH

1. *Research and Human Progress*

The material progress of society depends on man and his purposes on the one side, and on nature, which provides all the materials for living, on the other. This progress is effected by man adjusting himself to nature, or adjusting nature to his purposes. Both processes call for the use of imagination, intelligence and knowledge on the part of mankind, qualities that are partly inherent and partly acquired. Of the three qualities, the acquisition of new knowledge has proved the most amenable to organized effort, and in the modern world has become increasingly institutionalized, in schools, universities, laboratories. This organized search for new knowledge, termed *research,* has become an essential function of societies that want to do new things, or to do old things in new ways.

In the past the search for new ideas, or for new ways of applying existing ideas to the business of living, has been greatly dependent upon some individual's native ingenuity and reflection, or on chance discoveries. These elements of genius and chance will always remain important, and sometimes even dominant, factors in the development of knowledge. But with the growth of modern scientific methods, which proceed by observation and experiment, and by the systematizing of the resulting facts and relationships into truths or laws, the search for new knowledge, especially in the scientific and technical fields, has become more and more institutionalized and professionalized. It is these particular fields that produce most of the means to material progress. On the other hand, in the arts, as distinct from the sciences, in the development of literature, music or painting, new forms have to be put into practice by those who devise them, and therefore development of this kind does not lend itself quite so readily to institutionalization.

In the modern world (at least in western civilization), research in the sciences is being carried out more and more in institutions. Individual invention has been gradually giving way to co-operative effort and greater emphasis placed on team work of specially-trained scientists and technicians organized in research groups. In government agencies, in private firms, in universities, hospitals, and other such semi-public agencies, research organizations have become an integral part of our system. These institutions can greatly affect material progress, yielding increases in knowledge and power, sometimes at a steady rate, sometimes with an irresistible surge capable of opening a new epoch. The gain in knowledge and material power provided by such research institutions affords opportunity for social betterment—but of course the new knowledge or power in itself cannot guarantee such betterment, since it can be used equally for good or ill.

As the process of research became institutionalized, it also became professionalized. A new profession of research workers in scientific and technical fields (and to a lesser extent in others) has emerged as a significant occupational group—their quality, their numbers, and the facilities available to them, becoming an important determinant of the material development of the country. This new profession, although relatively small in numbers, is already specialized within itself, and tends to become more so as the complexity of scientific and technical knowledge increases. Any country concerned nationally with the pace of its economic development must likewise concern itself with the numbers of its research workers, the facilities available to them, and the standards of living offered them.

Research, even that which adds to the sum of human knowledge, does not of course always result in immediate application of the new knowledge to the business of living. The rate of application of new ideas or new ways of doing

things depends on many other kinds of conditions—on the kind of society, on its desire for change and material progress, on the initiative of those responsible for the economic processes, on the resources and capital available, and on the utility of the new idea, instrument, process or product. The rate of application of new ideas is a matter therefore of economic choice. Research can never be valued until its end-products meet the "test of the market". Although this report is not concerned with measuring the ultimate economic effects of research, some attempt is made to show their significance.

2. *Economic Significance of Research*

In industrial history, while it may be said that the first half of the 19th century witnessed the application of power to industry, the 20th century is seeing the application of science to industry. This use of science has revealed itself not only in the transformation of older industries, but in the creation of new industries associated with chemicals, radio, electronics, combustion processes, and now with atomic development. The tempo of the application of science to industry has increased greatly as a result of the Second World War.

The application of scientific discovery to industry is beginning to be described as a two-fold process—one in which there is scientific work proper, perhaps up to the pilot plant stage, and a second stage, now popularly referred to as the application of the "know-how". It takes both types of knowledge to effect a particular innovation. To know how to apply a given idea to industry, or how to adjust a plant or a process to a new idea, is partly a matter of engineering, but partly also a matter of organizational and managerial skill. It follows therefore that the application of scientific discoveries is much more than a matter of research in laboratories: that is a necessary condition for progress, but by itself it is not sufficient. To make such discoveries effective, the other process—the application of "know-how"—is also required. It will be observed that so far as the application of science to industry may be characterized as an essential of modern industrial development, there is a strong tendency for the highly-developed countries to develop further since it is the industrially-advanced nations that are likely to have the research facilities and the "know-how". This is true not only between countries, but also *within* countries, the larger industries or firms being more likely to engage in research and to know how to apply it.

While research and "know-how" have become necessary conditions for the introduction of scientific discoveries to industry, two points have to be borne in mind. (1) Not *all* industrial development is dependent on research: there are still innovations and adaptations being made, and to be made, that can emerge from individual ingenuity or chance. But an increasing portion of development does depend on research. (2) Research and "know-how" are necessary but alone are not sufficient to ensure the industrial application. The research may be continuous, but the application tends to be discontinuous through time, the application depending on economic choice on the part of the management concerned (whether public or private). Usually, because of demand conditions, risk-factors, supplies of capital, etc., certain periods of time appear more propitious than others for innovating or adapting processes, and in the past such changes have been frequently introduced in waves that are associated with "prosperity". It should be noted however that as research becomes more institutionalized, and as large corporations control many of the important and new fields of industrial endeavour, the application of the new processes, products or ideas tends to become more automatized than formerly. The new things tend to grow out of the old, rather than alongside the old as was the typical case in the 19th century.

The full economic significance of research can be gauged therefore only by considering the economic process. The economic situation at any time is condi-

tioned broadly by three sets of factors—the population (its numbers and quality, its preferences, etc.), the institutional conditions (organization of the state, families, firms, legal framework, etc.), and the technological environment (the resources, and the knowledge and capital used for their development, the methods and processes of production, etc.). These three sets of inter-related data or conditions provide the framework of any economic system; between them they determine its structure, and they determine the dynamic changes within that structure which in turn may alter the very structure itself.

The results of research, as it adds to knowledge and as that knowledge is applied, affect all three determining sets of conditions. The first is the population factor. New knowledge derived from research in medicine, physiology, etc., is now constantly affecting the human factor—adding to the length of life, combatting disease, reducing industrial fatigue, and in these and other ways increasing the material effectiveness of the individual as a producer. Likewise new knowledge of dietetics, health-requirements, etc., affect the individual as a consumer, conditioning his demands for food, health and health services, his use of leisure, etc.

The second is the institutional factor. It determines economic development but is itself in a process of constant modification. Even the structure of world power has altered according to the ability of various nations to make practical use of new knowledge, both in peace and in war. It is not necessary to elaborate on the shifts in institutional conditions, but it is obvious that the development of new knowledge has been associated with the growth of corporations and large-scale organizations, and with the subsequent shifts in the status of owners, managers, and labour. Material progress required the institutionalization of research itself. The pace of material progress now, and in the future, is directly related to the volume of research expenditure and the quality of the work done by the research personnel. This is a condition of the economic system in an age in which the application of scientific discoveries to industry has become a dominant characteristic of economic development.

The third or technological factor determining the economic situation is perhaps being more greatly affected by the new knowledge systematically provided by research. Research points up new things that may be done, or how to do old things in new ways. It provides the knowledge that may be used to create new industries, like radio, new products like plastics, new processes like those yielding rayon or nylon, new methods of production, new sources of supplies, new sources of power, like jet-propulsion. Apart from such innovation, new knowledge provided by research indicates new ways of doing old things—ways of producing at lower cost, or ways of producing a higher quality of goods. As this knowledge is applied the structure of the economic system is changed. The 20th century has witnessed a considerable change in agricultural methods and a new diversification of the manufacturing industries, with all the attendant shifts in methods of production, in the organization and financing of industry. Each structural change —the mechanization of agriculture, the development of the electrical industry, the coming of the automobile, etc.—has resulted in a new dynamic in the economy, as the new industry or process was developed, and as it competed with existent industries for its place among consumers' satisfactions.

These dynamic aspects of the significance of research are discussed below under two main headings: (a) the effect on productive capacity; and (b) the effect on the level of economic activity.

(a) *The Effect on Productive Capacity*

The important influence that research has had on economic development in modern industrialized nations can be seen from the way in which applied science

is gradually permeating all branches of economic activity. The process has grown out of the realization that discoveries and inventions resulting from research can make a significant contribution towards increasing the productive capacity of a country. The effects which brought about an expansion in productive capacity have taken different forms. In some instances they involved a reduction of human effort necessary to satisfy existing wants. Such was the case when the invention of the power loom replaced the hand loom. As a result some of the unspent energies were released to serve other purposes and production costs of woven products were lowered, resulting in an expanded market. In other instances new devices or facilities were created to satisfy existing wants or newly developed needs, such as the invention of the cinematographic process. This meant an improvement of the standard of living for large sections of the population, the creation of new consumer wants and outlets for energies saved in other processes due to technological advances.

But increased productive capacity contributes to human welfare only if it is used for this purpose. This is not the case if some of the resources freed and new capacities created remain idle as they did in most countries during the depressed 'thirties. Hence, a great deal of endeavour is directed towards increasing the demand for the goods and services that may result from a rise in productivity. In part this is accomplished by endeavouring, through the introduction of improved processes or the increased efficiency of labour, to reduce unit costs, thus assuring a widening market. Rising productivity is also affected by the development of new products which stimulate demand. To this end research can make a significant contribution.

Through the proper use of scientific and technological research, the efficiency of plants can be raised, the productivity of labour increased, costs reduced by use of better equipment, methods of production improved, materials used more economically, and new and up-to-date articles produced for an ever-changing market. It is through research that new designs can be developed to make goods more attractive, new ways found to improve the quality of the article produced or the service rendered, and new knowledge of materials and methods made available to industry. Research can also contribute to the better health and greater efficiency of the labour force, resulting in improvement in the quality of goods produced and an increase in the volume turned out by each worker. Science also opens up new occupations, both in the trades and in the professions, thus improving and broadening the opportunities available to workers for finding congenial employment suited to their capacities. Through scientific and technological research, the total output of a country can be improved in quality (i.e. better products) and increased in quantity (i.e. more goods at the same cost). Further, through the application of scientific methods in business, valuable economies and simplifications can be effected. The forces thus released, if absorbed in the economic process, will contribute to a further rise in the quantity of goods and services available for consumption or for investment into productive assets.

(b) *The Effect on the Level of Economic Activity*

A high level of economic activity associated with a rising real income and "full" employment can only be accomplished if all the goods and services produced in a country are absorbed. But as past experience shows, these conditions did not prevail in many countries for any length of time since some segments of economic activity (for example, investment by business enterprises and exports) were subjected to substantial variations. Any impact that research could exert in contributing to a reduction of fluctations of such vulnerable commodity flows as investment and exports could have a significant bearing on total economic activity. While these effects on the dynamics of an economy may be of major import, research, as indicated below, has also direct employment and income-creating effects.

(i) *Direct Effect.* Research involves the disbursement of expenditures designed to create new assets involving outlay for capital purposes, such as the construction of a new laboratory or the acquisition of machinery and equipment, and for operating purposes, such as salaries of research personnel, wages of auxiliary working staff, rentals, materials for consumption in experiments. Thus, research expenditures have an immediate employment and income-creating effect that may range over a great variety of human endeavour. But because research expenditures in most countries have involved only a small portion of total national outlay, the *direct* effect of such expenditures has, of necessity, been limited.

The direct impact though is perhaps greater than appears to be indicated by the size of the outlay involved because of the incentives provided to persons either aspiring to do research or actually engaged in research. Well-trained scientists are the product of education and experience acquired over a long period of years and the capacities they possess, though they cannot be expressed in monetary terms, contribute greatly to the improvement of the economic well-being of the people in a country. Encouragement to research, as demonstrated perhaps by large research expenditures, means, therefore, not only jobs for those scientists already engaged in research but also represents an incentive to others to follow this profession. Adequate research facilities and remuneration, together with an atmosphere conducive to research, mean also that a country can retain its own scientists, (and possibly attract scientists from other countries) a point of particular importance for Canada. If insufficient incentives for research are provided, a country stands to suffer a serious national loss through the emigration of some of its scientists who will be attracted by facilities available and incentives offered in other countries.

(ii) *Indirect Effect.* In the more recent past, discoveries and inventions resulting from research have contributed to the emergence of such major industries as the railroad, automotive, chemical, and radio industries which have had a dynamic effect on economic advancement. These developments have accelerated technical progress. The profound structural changes caused by these innovations opened up opportunities for real investment in an ever-spreading network of complementary industries as well as in the major industries themselves. In the field of investment these discoveries and inventions resulting from research can have great significance and because of the nature and pace of modern science their importance in the future may be even greater. The only way in which new techniques, processes, and products of any significance resulting from research can be introduced is through large capital expenditures. In the past investment outlay by business enterprises has been subject to substantial fluctuations and has often fallen below the size necessary to maintain economic activity on the scale desired. Since economic prosperity is dependent upon the rate of accumulation of real capital as well as the absorption of all goods and services produced by a community, research, if it results in the opening of new extensive investment opportunities, can contribute significantly to the reduction of variations of this particular commodity flow.

Prosperous economic conditions in Canada, whose economy is characterized by the specialized nature of her resources coupled with a comparatively small population, depend greatly on a large measure of trading with foreign countries. In the export field as in the investment field, this country has experienced great variations in the level of its foreign trade over comparatively short periods. If Canada is to compete in the world markets as an industrial nation and maintain her position as an exporter she must do everything in her power to ensure a high degree of efficiency of both management and labour, install up-to-date machinery

and equipment, and bring to bear the ingenuity of her people to produce commodities in demand abroad at costs that foreign buyers can afford to pay and in the form that meets the needs of other countries. Changes in taste or a decline in the competitive position of Canada as an exporting country can be met by increased efficiency in old export trades, by raising the quality of the product to a competitive level, or by the development of alternative export goods. Greater diversification in the classes of articles manufactured for export will tend to offset some of the periodic disturbances caused by a changing level of foreign demand. Development of new processes and products in this country is important to enable Canada to keep abreast of scientific and industrial progress made abroad. In the export field as in the investment field, research can play a major role.

There are many other indirect effects of research which, though they may not be as important in their impact on the level of economic activity, nevertheless have economic implications that are real enough. For instance, scientific activity can play an important part in protecting the consumer through the establishment of standards (enforced by the government) to ensure good quality and fair price. Thus purchasing power may be conserved and become available to purchase other commodities produced by the community. There are few fields of economic activity then that could not benefit either directly or indirectly from discoveries and inventions resulting from research.

(iii) *Effect on Structural Change.* Discoveries and inventions have employment-saving effects, for instance, a new machine to replace hand labour, and employment-generating effects, for instance, the discovery of a new resource to set a new economic process into motion. In both instances, discoveries and inventions may have a significant impact on the structure of industry and consequently affect the level of economic activity.

As a result of discoveries and inventions whole industries may disappear and new ones may take their place. On the other hand, new discoveries may result in adaptations of old industries to overcome adverse influences, whether natural or man-made. But whether they will or not, depends to a great extent on the quick and imaginative adaptability of entrepreneurs to adapt new processes and new products in an attempt to keep abreast of new developments, as well as changes in consumers' needs and demands. To give two examples:—communities in Canada that were once thriving centres of the wooden shipbuilding industry are now ghost towns because of failure to adapt or change their business to counteract the new developments in steel. On the other hand, the use of research to combat the disastrous effects of rust disease on wheat in Manitoba has enabled wheat farming to remain the important industry it is throughout the Prairies today.

Structural changes arising out of technological progress often create problems that could be solved by further developments on the part of science. For many years solid fuels had almost exclusively dominated the market for heating and industrial purposes. As fuel oils, gas, and electricity became more readily available and competitive, they became more popular than coal due to ease and cleanliness of their application, and the introduction of simplified automatic controls in their use. In order to improve their competitive position, the solid fuels and combustion equipment industries, through research, developed improved equipment including stokers, ash conveyors, and automatic controls. In fact, developments are under way which may result in replacement of oil-fired gas turbines by those utilizing pulverized coal.

Another instance is the changing fortune of the carbide industry. Early in this century research work brought about the establishment of a carbide industry which built up an extensive enterprise in small scale and portable illumination equipment. Later, electricity replaced the use of carbide in this field. Further research and development work enabled the carbide industry to build up an even more important enterprise, as carbide is now the base material for a great number of chemical products, such as acetic acid, celanese, and vinylite plastics which, among other things, are used for table coverings, shower curtains and rain-proof garments. An important use of carbide is production of acetylene gas for oxyacetylene welding and metal cutting.

The discovery of a hitherto unknown resource that may bring about major structural changes is the development of atomic power. If used for peaceful purposes, atomic power may open up entirely novel fields for economic activity. It may thus create different ways of filling existing human wants and contribute to the development of wants that can be satisfied only by the growth of an entire new industry accompanied by the reorientation of a host of complementary industries involving those that already exist and others that would come into operation.

Growth and decline, both are inherent elements of the process of economic change. Discoveries and inventions resulting from research have in the past been partly responsible for such change and are likely to increase their influence on future development.

In summation, scientific research provides both basic knowledge and the means of putting this knowledge to practical use in the economic advancement of a country. In applying science to economic ends, the productive capacity of a country is increased, thus laying the basis for the improvement of the national standard of living of the people in the country. Through its possible stabilizing effects on important segments of total commodity flow, particularly in the field of investment and exports, science has a bearing on the level of economic activity. It also brings about structural changes that are essential to economic development. Research activity on a large scale provides ample opportunities for the creative abilities of scientists, and the country which provides such facilities will benefit greatly from the results of scientific investigations. All this creates a favourable climate for business activity. It opens up fields for imaginative enterprise and individual and corporate initiative, all factors that can contribute significantly to the maintenance of a high level of employment and income in a country.

3. *Definitions of Research and Scientific Activity*

Research is defined as the purposeful seeking for new knowledge or new ways of applying knowledge, through careful consideration, experimentation and study. It involves investigations directed towards the discovery of previously unknown scientific facts or principles, and the new application of known facts or principles.

Because of the wide range of possible definitions of both research and scientific activity, (the latter encompassing a much wider field than research in the restricted meaning of the term,) a schedule has been drawn up to show the various phases that make up scientific activity. The term "research" may be applied to any one or a combination of the activities listed but for the purpose of this report, the definitions as shown in Schedule A are adopted.

SCHEDULE A.—RANGE OF DEFINITION OF RESEARCH AND SCIENTIFIC ACTIVITY

Item No.	Type of Scientific Activity
1	Pure or fundamental research
2	Background research (surveys, descriptions of basic facts, determination of standards)
3	Applied or practical research
4	Research (Items 1 to 3)
5	Development (based on research)
6	Research and development (Items 4 and 5) (1)
7	Analysis and testing
8	Total Scientific Activity (Items 6 and 7)

(1) Items 1 to 6 include testing, analysis and other types of experimental work where they form a part of, or are directly related to, research and developmental activity.

Three major types of research work can be distinguished: (a) pure or fundamental research; (b) background research, and (c) applied or practical research.

Pure or fundamental research (Item 1) is defined as an investigation directed towards a discovery of previously unknown facts resulting in general knowledge and understanding of nature and its laws. The material application of the results of pure or fundamental research are not, of necessity, a basic consideration in undertaking this type of research but it forms the fundamental basis for all applied research and development work.

Background research (Item 2) is defined as the collection and analysis of initial data for both pure and applied research. It consists of surveys and descriptions of basic facts such as the preparation of accurate geological maps, the determination of physical and chemical constants, the description of species of animals, plants, and minerals, the determination of standards such as those established for hormones, drugs, etc.

Applied or practical research (Item 3) is defined as an organized effort directed towards new applications of known scientific facts or principles to practical problems. As indicated previously, the distinction between fundamental and applied research is not always a hard and fast one and both contribute to progress in scientific knowledge. To give an instance, the study of the principles of electronics would be classed as pure research while the investigation of ways and means to use electronics in the home or factory would be applied research.

The lines separating these various groups of research activities are not always clear-cut. Some operations may, in one investigation, be part of fundamental research but the same operation may be repeated again in applied research e.g., testing. Similarly, background research may provide basic information both for fundamental and for applied research. But in developing an economic concept of research activity it is desirable to select a classification which allows the separation of stages through which discoveries and inventions go before they become

part of the economic process. These stages, which commence in the realm of the mind, lead through experimentation and development to the trial stage of practical application of discoveries and inventions. Such a classification would be justified alone on the ground that evaluation of material things is possible—though the difficulties of measurement are formidable at times—while this is not feasible as long as discoveries and inventions remain in the realm of the mind. But apart from this factor, research achieves economic significance only through its effect of satisfying human wants. Fundamental and background research are both essential elements in the research process and are actual forerunners of applied research. But only through their application can both fundamental and background research achieve economic significance. For instance, with the discoveries of principles relating to electricity (the result of fundamental research), it was possible to build radios (the result of applied research).

The combination of *pure, background, and applied research,* represents activity covering both the exploratory and practical stages of endeavour (Item 4). Surveys, analysis, testing and other related work, are all included in research activity when forming part of or directly related to this work.

The next stage in endeavouring to incorporate the results of research into the economic process is the development stage. *Development* based on research (Item 5) is defined as all work required, after the initial research on laboratory (or comparable) level has been completed, in order to develop new methods and products to the point of practical application or commercial production. Pilot plant activities are included under this heading.

The sum total of Items 4 and 5, called *research and development,* cover the major fields of scientific activity (Item 6). But there are other activities which, though they use scientific principles, do not add to or increase human knowledge and are not included in any of the items listed above. These are *analysis and testing* (Item 7) and cover routine laboratory analyses or tests to conform with generally accepted standards, whether in the industrial field of plant and quality control or in the examination of agricultural and other products to ensure conformity with government acts and regulations.

The sum total of activities listed under Items 6 and 7 is considered *scientific activity* in the broad sense (Item 8) and can cover such phases of endeavour in the physical and natural sciences, the social sciences or the humanities. The physical and natural sciences deal with material realities, including the human body, and cover, in the present state of development, the largest effort in the scientific field. Various classifications into groups, sub-groups and further subdivisions, are possible in the natural and physical science fields depending on the purpose for which such a classification is made, but the extensive inter-relationship of the various sciences causes overlapping that is impossible to eliminate. Among the more important groups are included: mathematics, astronomy, physics, chemistry, geology, biology, medicine, engineering, agriculture and other sciences relating to natural resources, chemical technology, and military science. Similarly diversified are the social sciences dealing with man in relation to his surroundings and fellow men, covering the realm of the mind and human behaviour. It includes such subjects as sociology, psychology (social and educational), education, economics, statistics, political science, public administration, law, history (social and institutional), geography (human, economic and political), and anthropology. The humanities cover such broad groups as philosophy, history, literature and languages.

Because of the wide range of human activity that can be described by the use of the terms *research* and *scientific activity* it is necessary for a proper appraisal

to state specifically what phases of activity are covered. The measurement on which this report is based relates to scientific activity by the Federal Government in the natural and physical sciences (see subsection 5).

There are two important adjuncts to research and other scientific activities that have not been specifically mentioned in Schedule A, as they cannot be defined as scientific in the accepted meaning of the term. In measuring scientific activity on the basis of expenditures, it is desirable to include outlay for administrative functions where they are directly related to research and other types of scientific work. This has been done in the present survey. It should be noted, however, that there is an essential difference between research and administrative functions. Administrators are concerned mainly with the application of established policies, and in order to ensure greater efficiency, are under constant pressure to regularize and simplify procedures. Research workers, on the other hand, are exploring the unknown and cannot, therefore, standardize their approach to a problem or the procedures used in their research work. The results of research, particularly pure research, cannot be determined or planned in advance, as they are sporadic and uncertain. It is essential, therefore, that research programs should be flexible, and research workers untrammelled by other and conflicting responsibilities. To make the most efficient use, then, of a research organization, it is necessary to provide a protective belt of administrators to manage that part of the work that can be routinized.

Another necessary adjunct to research is the proper organization of the results obtained, and their dissemination to industry and other ultimate users. A certain amount of this educational work is done by most research agencies through the publication of scientific articles and pamphlets, and through direct contacts with users of the results of research through what is known as extension work. Expenditures of this type, if directly related to research and scientific activity, are also included in the survey that follows.

4. *Government and Research*

To appraise the significance of the phases of research and other scientific work in Canada covered in this study, it is desirable, in the absence of authoritative and complete quantitative information covering all activity in the country, to provide some indication of the institutional framework within which research and scientific work are carried on.

The growth of research and scientific activity in this country has been characterized by a harmonious development with business enterprises, governments and semi-public institutions complementing one another.

In the early days of Canada's development, the improvement of old and the discovery of new industrial products or processes depended on the initiative, skill and ingenuity of the individual entrepreneur or the technician or craftsman working for him, but, as time went on, specialization in this field grew. It developed, particularly during the last three decades, into co-operative research endeavours undertaken by specific companies, and in some instances by industries as a whole, e.g., research, development work, analysis and testing, carried on by the Pulp and Paper Research Institute of Canada and the Canadian Research Institute of Launderers and Cleaners. Business enterprise in Canada thus carries part of the research and scientific work at present under way. However, the number of firms engaged in this work as a percentage of all business firms in Canada is not large and in comparison with the United Kingdom and the United States, research by private firms in Canada is rather small. A good deal of reliance is placed on obtaining results of research work undertaken by parent companies in the United States but a trend towards more research activity in Canada is noticeable.

Since the beginning of the twentieth century and particularly after World War I, all three levels of government (Dominion, provincial, and municipal), have participated to an increasing extent in research and related activities. Research and scientific work in semi-public enterprises (e.g., utilities) and in semi-public institutions (e.g., universities, hospitals, and research foundations), experienced a similar growth.

This development has brought about a division of labour with business enterprises mainly concentrating on problems of applied research, development based on research, and analysis and testing, that have a direct bearing on their own requirements, while the various government groups within Canada, universities, and other research institutions, are concentrating more on fundamental research and those phases of applied research which complement activity in business enterprises. ([1])

Among government groups engaged in research and other scientific activities, the Dominion Government carries out a major portion of the work involved ([2]), although the provinces through the universities and other provincial agencies play an important part in Canada's scientific efforts. At present eight Federal Government departments, in addition to the National Research Council, are engaged in either one, several, or all phases of scientific activity. The departments include: Agriculture, Fisheries, Mines and Resources, National Defence, National Health and Welfare, Public Works, Reconstruction (formerly Munitions) and Supply, and Transport.

The work undertaken covers fundamental research (confined for the most part to the National Research Council); applied research in resource development and industrial fields; development of research through the pilot plant stage in the case of a new product for manufacture, or comparable stage in the case of resources (e.g., to the point where an agricultural product can be produced by farmers generally); and analysis and testing to ensure conformity with government regulations or generally accepted standards. While most of the activities are carried out in laboratories, some of the work is done in the field, e.g., agricultural and forestry tests undertaken on experimental farms or forestry stations. In the latter instance, only work that is comparable to a laboratory level is considered scientific activity. Inspection work relating to the maintenance of government regulations and standards is considered in the concept adopted in this report as part of the administrative process. While background research is a necessary part of research work in all the departments, it also cuts across many of the activities relating to the conservation and development of natural resources. Within this category fall many of the research activities pertaining to those basic surveys (e.g., geodetic and geological surveys) that are essential to proper resources planning, and necessary for the compilation of maps, inventories and other descriptive material. Before experimental projects in agriculture, forestry, or fisheries can be undertaken preliminary surveys and investigations are often required to collect basic data prerequisite for more intensive research (e.g., soil surveys, biological studies, forest site-type classifications). (For a detailed description of research work and related activities currently undertaken by Federal Government departments see Appendix).

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(1) For a discussion of the various types of scientific activities carried on in Canada, see *Scientific and Industrial Research in Canada*, Ottawa, 1940, N.R.C. No. 939.

(2) For a description of research institutions in Canada, including suggestions for a "national plan of research", see submission on *The Organization of Research in Canada* by the National Research Council to the Royal Commission on Dominion-Provincial Relations, Ottawa, March, 1938. See also *Survey of Scientific and Industrial Laboratories in Canada*, Dominion Bureau of Statistics and National Research Council, Ottawa 1941, N.R.C. No. 961.

5. *Coverage of Survey and Sources*

The results of the survey on research and other scientific activities discussed in Section II and shown in tabular form in Section III relate to scientific work undertaken by the Federal Government in the physical and natural sciences during the fiscal years 1938-1946.

Statistical information is provided for the various components which make up scientific activity shown in Items 4 to 8 in Schedule A. Because of the close inter-relationship of the various types of research undertaken by the Dominion Government (Items 1 to 3), only totals for research are shown (Item 4).

A separation is provided between military and non-military expenditures. Military expenditure covers outlay on all research, development, or analysis and testing undertaken for the Armed Services, either by themselves or by other departments on behalf of the National Defence Department. All other expenditures are classed as non-military activities.

Research and other scientific activities relating to agriculture, fishing, mining, and forestry, are separated from other non-military scientific work in order to show the role played by investigations designed to improve the use and assist in the development of the natural resources of the country.

The survey is based on returns from Federal Government departments and agencies. Some of the items which make up expenditures on research and related activities appear in the Dominion public accounts under various headings. Special computations and some estimates were necessary in order to obtain the information in the form desired. In instances where the same expenditure covers research and other technological investigations, allotment to the various components of scientific activity (Items 4 to 8) was made on the basis of estimates.

Total expenditures include: salaries and wages, cost of materials used, maintenance of research facilities, and capital expenditures on equipment and structures, whether carried out by the Public Works Department or by the departments concerned. Figures include expenditures on all scientific activity carried out by the department, even if undertaken on behalf of, and paid for by another department, but research purchased from other departments and agencies was omitted. This was done in an attempt to avoid overlapping, for in many cases one department advances funds to another to do research work on its behalf. In some instances payments were made to outside agencies, particularly during the war years. As far as possible, this latter type of expenditure has been eliminated as the survey covers only research work actually undertaken by Federal departments or agencies.

All figures on research and scientific activity for the period 1938-1946 relate to fiscal years ending the following March 31st. Up to and including 1945, expenditure figures were based on special compilations of actual outlay as reported in the public accounts. Figures for the year 1946 (that is, the fiscal year ending March 31st, 1947) are estimates. In preparing these, account has been taken of the fact that not all funds voted will be used up because of shortages of research personnel and certain types of equipment and materials.

Data on employment and earnings of persons engaged in research and other scientific activities have been compiled only for the more recent past and relate to 1944-1946. For this period the survey covers the number of professional and non-professional personnel (in terms of man-years) employed in research, development, analysis and testing, together with corresponding salaries and wages paid to this personnel. In computing man-years, one employee engaged for a full

year was considered as one man-year. Where an employee was engaged part time in any of the categories, that proportion of time was indicated as part of a man-year. Similarly, with respect to salaries and wages for part-time workers, the amount of salary in any category was pro-rated according to the time devoted to that field. For the purpose of this survey, a professional was an individual possessing a university degree in science or engineering, or a diploma from a recognized technical institute, or professional membership in a recognized technical or scientific society.

Data on gross national expenditure and net value of production in primary industries relate to calendar years. Figures on total Dominion Government expenditure on goods and services relate to fiscal years. (Data by courtesy of the Dominion Bureau of Statistics.)

6. *Appraisal of Measurement*

It bears emphasis that measurement of expenditures for research and related activities, or employment provided by such outlay, discussed in the following sections, is only one of several ways of indicating the contribution of the Dominion Government to scientific activity in Canada. More important still would be the measurement of the economic impact that discoveries and inventions resulting from government research have had on industry and resource development, if such measurement were possible with any degree of reliability. But no quantitative appraisal of this sort is attempted in this report. Three examples, however, of the more significant accomplishments of Canadian Government research are given below to illustrate the tremendous possibilities that open up as the result of a well-integrated research program. (Additional references to significant research projects currently under way are given on page 41 in Appendix).

Before the war Canadian starch requirements were provided from imported corn. When corn became scarce through shipping and other shortages during the war, attention was turned to the use of wheat as a raw material. Patient research and development work on both the laboratory level and in the pilot plant stage yielded a method for obtaining starch from either flour or ground wheat. A number of Canadian companies introduced this new process during the war years. The process proved so successful that it is being continued, thus providing new uses for one of Canada's most important staple products.

As a result of research, a method was developed for obtaining magnesium from dolomite, a mineral available in great quantities in many parts of Canada. A Canadian company has been formed to produce magnesium by this process. Thus, research work brought about the development of a new process, the creation of a new industry and the new use of Canadian raw material, bringing additional employment and income to several hundred Canadians. ([1])

An important discovery in the field of separating minerals from their ores was the development of the flotation process which makes it profitable to re-work the tailings from earlier extraction processes as well as develop more extensive but lower grade ore bodies than those which could be economically worked by earlier processes. This process, although developed abroad, was adapted to Canadian needs through private and government research and development work. In fact, this process has probably made a larger contribution to the mineral industry in Canada than any other single discovery.

([1]) For other examples of the effects of Government research, see *The National Research Council in the Service of Industry*, statement by C. J. Mackenzie, President of the National Research Council, Ottawa, 1946, N.R.C. No. 1352.

SECTION II. FACTUAL SUMMARY

1. *Research and Gross National Expenditure*

Research and development work in the natural and physical sciences undertaken by the Dominion Government has increased substantially in the eight-year period under review. In the fiscal year 1945-46, expenditures for this type of work amounted to $34.5 million, about seven times the $4.9 million expended in 1938-39. What this means in terms of utilization of productive facilities can be seen in broad prospective by comparison with gross national expenditure and with Dominion Government expenditure on all goods and services. During the early part of the period in question government outlay on research and development comprised only about one-tenth of 1 per cent of gross national expenditure. This proportion had increased to about one-third of one per cent by 1945, but there are indications of a slight drop in 1946. On the other hand, the increase in government research expenditure did not keep pace with the rise in government outlay on all goods and services. Accordingly research and development expenditure which made up about 2.3 per cent of total Federal outlay before the war was down to 0.3 per cent in the fiscal year 1942-43, but has since turned upward reaching about 1.1 per cent in 1945 (see Summary Table 1 and Figure I). This proportionate reduction took place in spite of the great expansion in military and atomic research that has been undertaken during the war and immediate postwar period. The explanation lies in the substantial increase in government expenditure during these years and also in the fact that Canada, while specializing in a number of significant fields of military research, relied heavily on research and development work carried on by the other Allies, particularly the United Kingdom and the United States.

SUMMARY TABLE 1.—GROSS NATIONAL EXPENDITURE, DOMINION GOVERNMENT EXPENDITURE FOR ALL GOODS AND SERVICES(1) AND FOR RESEARCH AND DEVELOPMENT, 1938-1945

Year	Gross national expenditure(2)	Dominion Government expenditure on goods and services(3)	Dominion Government expenditure on research and development(3)	Research and development by Dominion Government as a proportion of	
				Gross national expenditure	Total Dominion Government expenditure
	$ millions	$ millions	$ millions	percent	percent
1938	5,075	209	4.9	0.10	2.34
1939	5,495	255	5.8	0.11	2.27
1940	6,628	895	6.2	0.09	0.69
1941	8,335	1,491	7.6	0.10	0.51
1942	10,296	3,813	11.3	0.11	0.30
1943	11,124	4,572	16.3	0.15	0.36
1944	11,771	3,941	23.1	0.20	0.59
1945	11,478	3,109	34.5	0.30	1.11

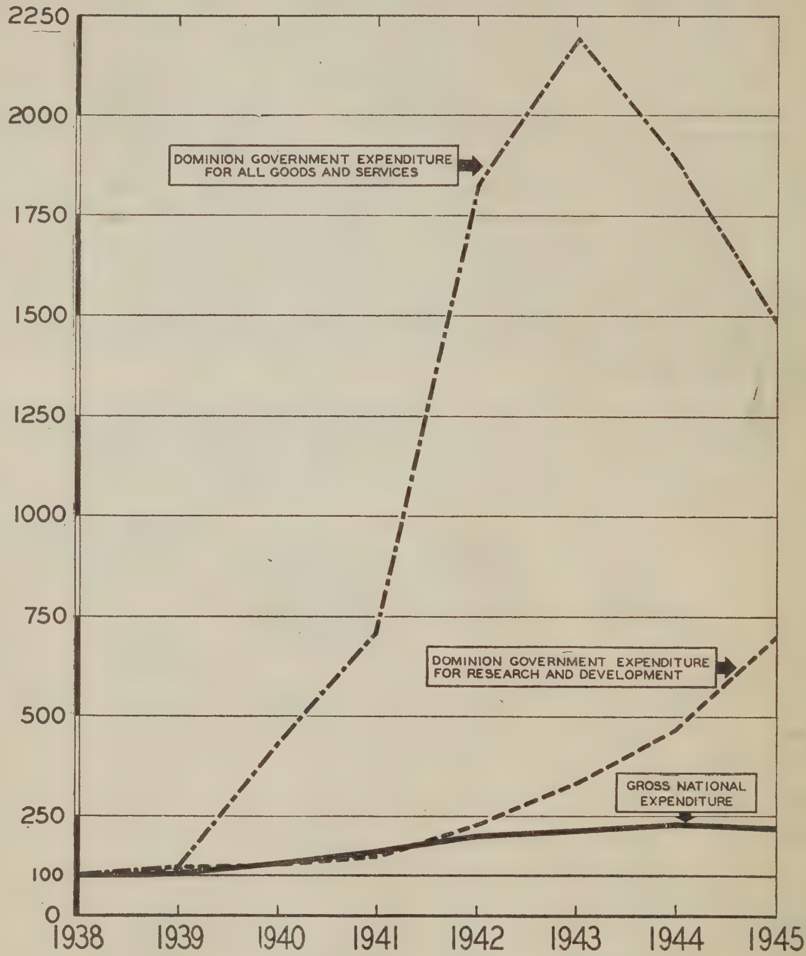
(1) The figures shown are estimates of expenditures on goods and services which exclude transfer payments to other governments, e.g., provincial subsidies, and to individuals, e.g., unemployment insurance benefits. Excluded also are changes in non-war inventories held by government agencies, e.g., wheat inventories and foreign capital movements on government account other than direct aid to the Allies.

(2) For calendar years.

(3) For fiscal years (corresponding most nearly to calendar year indicated).

FIGURE I

GROSS NATIONAL EXPENDITURE
DOMINION GOVERNMENT EXPENDITURE
FOR ALL GOODS AND SERVICES AND FOR
RESEARCH AND DEVELOPMENT
1938 – 1945
INDEX, 1938 = 100



SOURCE: SEE SUMMARY TABLE I (SECT. II) ECONOMIC RESEARCH BRANCH, DEPT. OF RECONSTRUCTION & SUPPLY

During the war years a major portion of Dominion Government expenditure on research and development was for military purposes. In 1944, for example, of the total of $23.1 million spent on research and development, about three-quarters went into military projects and only one-quarter into non-military undertakings. On this basis less than half of one per cent of total military expenditures by the Dominion Government went into research and development, but a substantially higher proportion, namely 3.6 per cent, of total non-military expenditures went into research serving civilian purposes (see Summary Table 2).

SUMMARY TABLE 2.—MILITARY AND NON-MILITARY EXPENDITURES FOR RESEARCH AND OTHER SCIENTIFIC ACTIVITY AND TOTAL EXPENDITURES, BY DOMINION GOVERNMENT, 1944.(1)

Type of Expenditure	Military(2)		Non-military		Total	
	$ millions	Per cent	$ millions	Per cent	$ millions	Per cent
Research	5.5	0.15	4.4	2.75	9.9	0.25
Development	11.8	0.31	1.4	0.88	13.2	0.34
Research and Development	17.3	0.46	5.8	3.63	23.1	0.59
Analysis and Testing	3.0	0.08	1.1	0.68	4.1	0.10
Sub-total Scientific Activity	20.3	0.54	6.9	4.31	27.2	0.69
Other Dominion Government expenditure(3)	3,760.7	99.46	153.1	95.69	3,913.8	99.31
Total Dominion Government expenditure(3)	3,781.0	100.00	160.0	100.00	3,941.0	100.00

(1) Fiscal year ending March 31st, 1945.

(2) Figures on military expenditures for research and other scientific activity are those so specifically classified in departmental estimates. In addition, there were substantial expenditures for equipment and stores used and personnel engaged in activities supplementary to work at the laboratory level. These latter expenditures are not included in this survey.

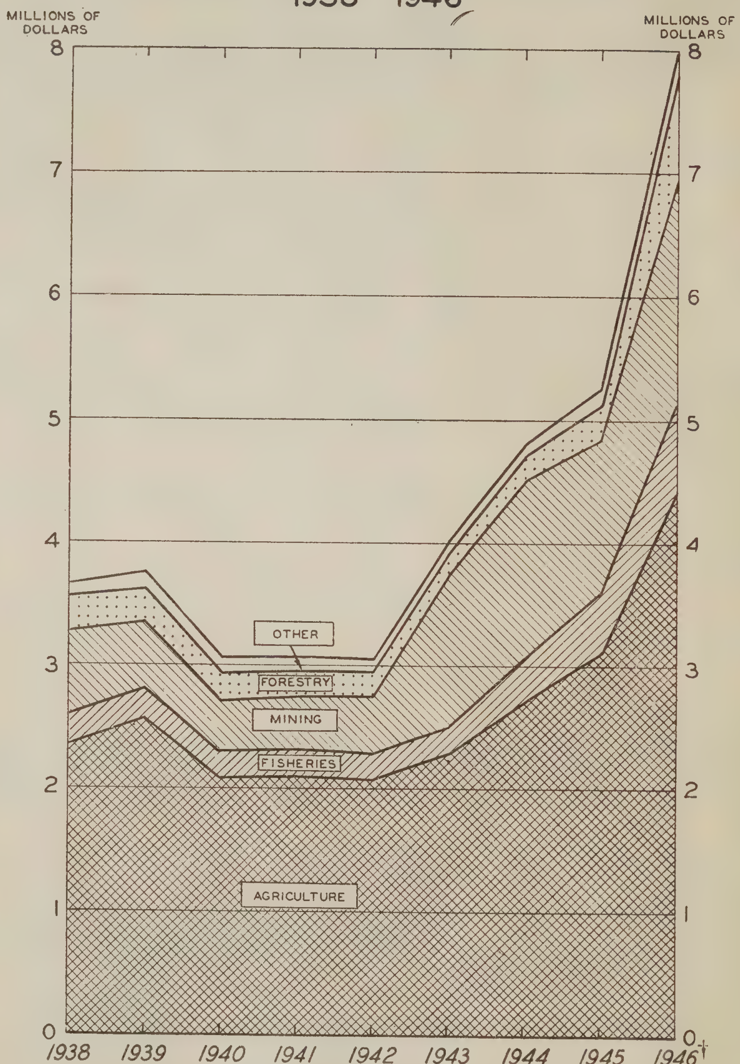
(3) Estimates relate to Dominion Government expenditure for goods and services as defined in footnote 1 to Summary Table 1.

2. *Research and Development Work Relating to Natural Resources and other Non-Military Activities*

The natural resources of Canada are an important factor in the Canadian economy and a significant part of research activity on the part of the Dominion Government is devoted to the fuller utilization of these resources, as well as to the improvement and conservation of the soil, forests, fisheries, etc. In 1939, four-fifths of non-military expenditures on research and development was spent on projects that had a bearing on the utilization of resources in such fields as agriculture, fisheries, mining, and forestry. In 1946, it is estimated that research and development expenditures will have doubled but the portion relating to resource development has dropped to a little less than two-thirds, because of the proportionately greater increase in other Federal expenditures of a non-military nature during the period between 1939 and 1946 (see Summary Table 3 and Figure II). Some of the research work done by the National Research Council has, both directly and indirectly, a bearing on resource development but no separate measurement of such projects has been attempted here.

FIGURE 11

DOMINION GOVERNMENT EXPENDITURES* FOR RESEARCH AND DEVELOPMENT RELATING TO NATURAL RESOURCES 1938 - 1946



* NON-MILITARY EXPENDITURES
† PRELIMINARY ESTIMATE

SOURCE: SEE TABLE 2 (SECT. III)

ECONOMIC RESEARCH BRANCH, DEPARTMENT OF RECONSTRUCTION & SUPPLY

SUMMARY TABLE 3.—NON-MILITARY RESEARCH AND DEVELOPMENT EXPENDITURES BY DOMINION GOVERNMENT RELATING TO RESOURCE DEVELOPMENT AND OTHER FIELDS OF SCIENTIFIC ACTIVITY, 1939 and 1946(1)

Item	1939		1946(2)		Percentage increase of 1946 over 1939 (Per cent)
	Expenditure ($000)	Per cent	Expenditure ($000)	Per cent	
Resource Development—					
Agriculture	2,581	55	4,441	35	72
Fisheries	241	5	740	6	207
Mining	550	12	1,753	14	219
Forestry	284	6	899	7	217
Miscellaneous(3)	122	2	146	1	20
Sub-total	3,778	80	7,979	63	111
Other non-military expenditures(4)	940	20	4,759	37	406
Total non-military	4,718	100	12,738	100	170

(1) Fiscal years (corresponding most nearly to calendar years indicated).

(2) Preliminary estimate.

(3) Includes such fields as geophysics, astrophysics, and photogrammetry, and work in anthropology and biology carried out by the National Museum of Canada.

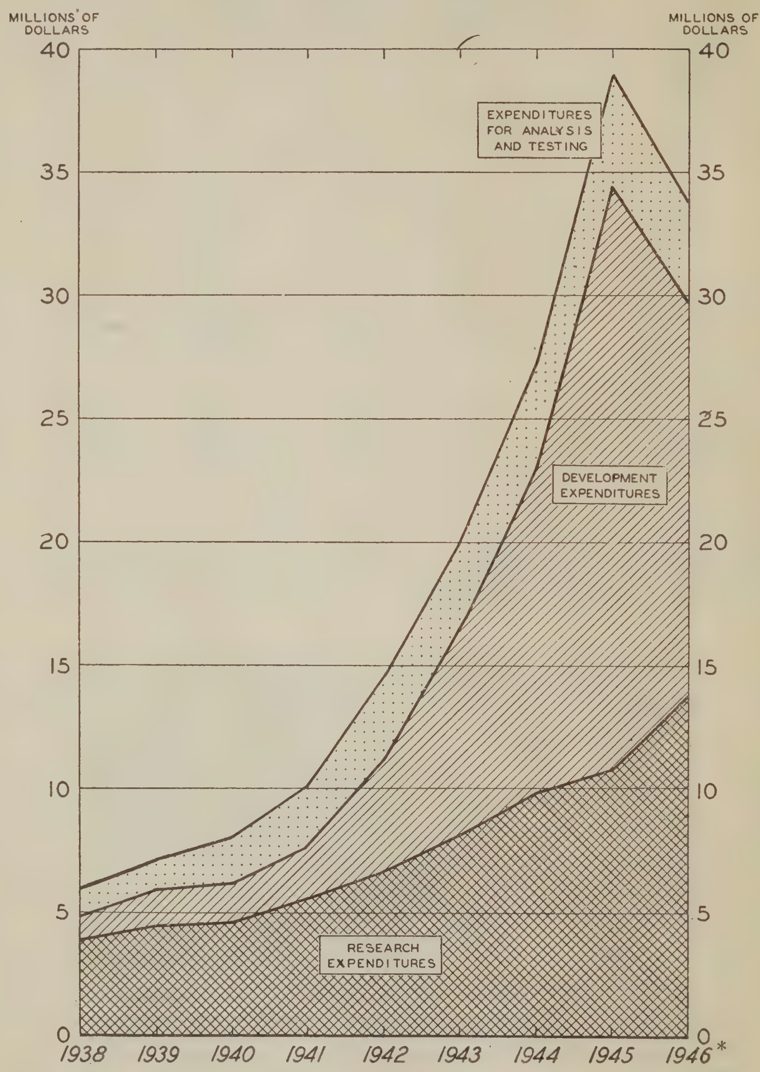
(4) Includes research and development expenditures by National Research Council, Departments of Public Works, Transport, and National Health and Welfare.

In comparing Federal expenditures for research and development relating to natural resources, with the net value of production (1) of those primary industries based on resources, not more than one-quarter of one per cent of total production was spent in 1945 for the above purposes. The proportion is smallest in forestry with 0.05 per cent, while in the fields of agriculture and mining, the figures are 0.24 per cent and 0.28 per cent respectively, with a high of 0.53 per cent recorded for fisheries (see Summary Table 4). The variance in these figures is accounted for in part by the division of responsibility in administering natural resources in this country. The Federal Government is responsible for the administration of most of Canada's maritime fisheries, but in agriculture, responsibility is shared with the provinces, while in mining and forestry, the provincial governments have full control over the administration of their resources. To appraise the full significance of government expenditure on research for resource development, it would be necessary to consider provincial expenditures in conjunction with Federal outlay in order to allow for the uneven division of responsibility.

(1) "Net Value" of production is defined as the value of that segment of production which is arrived at by deducting from the gross value of production the cost of materials, fuel, purchased electricity and process supplies consumed in the production process.

FIGURE III

DOMINION GOVERNMENT EXPENDITURES FOR RESEARCH AND SCIENTIFIC ACTIVITY 1938 – 1946



*PRELIMINARY ESTIMATE

SOURCE: SEE SUMMARY TABLE 5 (SECT II) . ECONOMIC RESEARCH BRANCH, DEPARTMENT OF RECONSTRUCTION & SUPPLY

SUMMARY TABLE 4.—ESTIMATED NET VALUE OF PRODUCTION AND RESEARCH AND DEVELOPMENT EXPENDITURES BY DOMINION GOVERNMENT, 1945

Type of Industry	Net value of production(1) $ millions	Dominion Government research and development expenditures(2) $ millions	Dominion Government research and development expenditures as a proportion of net value of production per cent
Agriculture	1,279.9	3.1	0.24
Fisheries	96.5	0.5	0.53
Mining	433.1	1.2	0.28
Forestry(3)	488.7	0.3	0.05
Primary industries(4)	2,298.2	5.1	0.22

(1) Calendar year, preliminary estimate, Dominion Bureau of Statistics.

(2) Fiscal year ending March 31, 1946, (non-military expenditures only).

(3) After elimination of duplication amounting to $62.2 million for forest production listed under agriculture (e.g., lumber from woodlots of farmers).

(4) Excluding trapping and electric power.

In spite of the fact that Canada now relies more heavily on the manufacturing industry as a wealth-producing factor than at any other time [1] nevertheless continued development of Canada's primary industries is essential in assuring this country's position among world producers in these fields and to contribute to the continuance of a high level of employment and income in Canada.

Non-military expenditures on research and development activities other than those relating to natural resources increased over 400 per cent in the period between 1939 and 1946. In this latter year, it is anticipated that these expenditures will represent 37 per cent of all non-military expenditures on research and development. This outlay covers work in the fields of transportation and health, as well as for the benefit of Canada's secondary industries. Most of the increase is in the work of the National Research Council which is engaged in a variety of research undertakings designed to be of service to Canadian industry (for details see Appendix).

3. *Expansion of Research and Other Scientific Activity*

Reference has been made previously to the fact that Federal expenditures relating to scientific activity increased since 1938, but this increase has not been in proportion to the rise in other Dominion Government expenditures. In spite of this, however, expenditures on all types of scientific activities by the Dominion Government is today about six times as large as it was nine years ago (see Summary Table 5 and Figure III). It rose from $6 million to about $34 million. Some 40 per cent of these $34 million went into research; a little more, about 48 per cent into development, including atomic energy development work, with the remainder of 12 per cent going into analysis and testing activities. The ratios as between research, development work, and analysis and testing, vary considerably over the period under review, with the Dominion Government in recent years expanding substantially its activities in the field of development based on research, in the first instance serving military purposes but in more recent times to meet peacetime requirements of Canadian industry (see Summary Table 6).

(1) *Location and Effects of Wartime Industrial Expansion in Canada, 1939-1944*, Department of Reconstruction and Supply, Ottawa, November 1945, pp. 13 ff.

SUMMARY TABLE 5.—EXPENDITURES FOR RESEARCH AND SCIENTIFIC ACTIVITY, DOMINION GOVERNMENT, 1938-1946(1)

Year	Research $ millions	Development $ millions	Research and development $ millions	Analysis and testing $ millions	Total scientific activity $ millions
1938	4.0	0.9	4.9	1.1	6.0
1939	4.5	1.3	5.8	1.3	7.1
1940	4.7	1.5	6.2	1.8	8.0
1941	5.5	2.1	7.6	2.5	10.1
1942	6.5	4.8	11.3	3.2	14.5
1943	8.1	8.1	16.2	3.9	20.1
1944	9.9	13.2	23.1	4.1	27.2
1945	10.8	23.7	34.5	3.4	37.9
1946(2)	13.7	16.2	29.9	4.0	33.9

(1) Fiscal years (corresponding most nearly to calendar years indicated).
(2) Preliminary estimate.

SUMMARY TABLE 6.—PROPORTION OF EXPENDITURES FOR RESEARCH AND SCIENTIFIC ACTIVITY, DOMINION GOVERNMENT, 1938-1946(1)

Year	Research per cent	Development per cent	Research and development per cent	Analysis and testing per cent	Total scientific activity per cent
1938	66.67	15.00	81.67	18.33	100.00
1939	63.38	18.31	81.69	18.31	100.00
1940	58.75	18.75	77.50	22.50	100.00
1941	54.46	20.79	75.25	24.75	100.00
1942	44.83	33.10	77.93	22.07	100.00
1943	40.30	40.30	80.60	19.40	100.00
1944	36.53	48.34	84.87	15.13	100.00
1945	28.50	62.53	91.03	8.97	100.00
1946(2)	40.41	47.79	88.20	11.80	100.00

(1) Fiscal years (corresponding most nearly to calendar years indicated).
(2) Based on preliminary estimates.

4. *Employment and Earnings of Personnel Engaged in Research and Other Scientific Activity*

About 4 per cent of the total personnel in the service of the Dominion Government are engaged in scientific work related to the physical and natural sciences.(1) Close to 5,000 persons(2) were working during the fiscal year 1945-46 on research and related scientific activities and it was expected that this figure

(1) The total number of Federal Government employees, both permanent and temporary including casual workers, was estimated at 135,000 as of December 31, 1946.
(2) In terms of man-years.

would be about 6,000 for this year. The relatively high proportion of scientific workers in comparison with the total number of government employees is rather notable when compared with the smaller proportion (approximately 1 per cent) of total Federal expenditures spent on scientific work. This difference is in part due to the fact that a larger proportion of research expenditures is spent on salaries and wages than the proportion of expenditures for other goods and services, many of which are purchased from private industry.

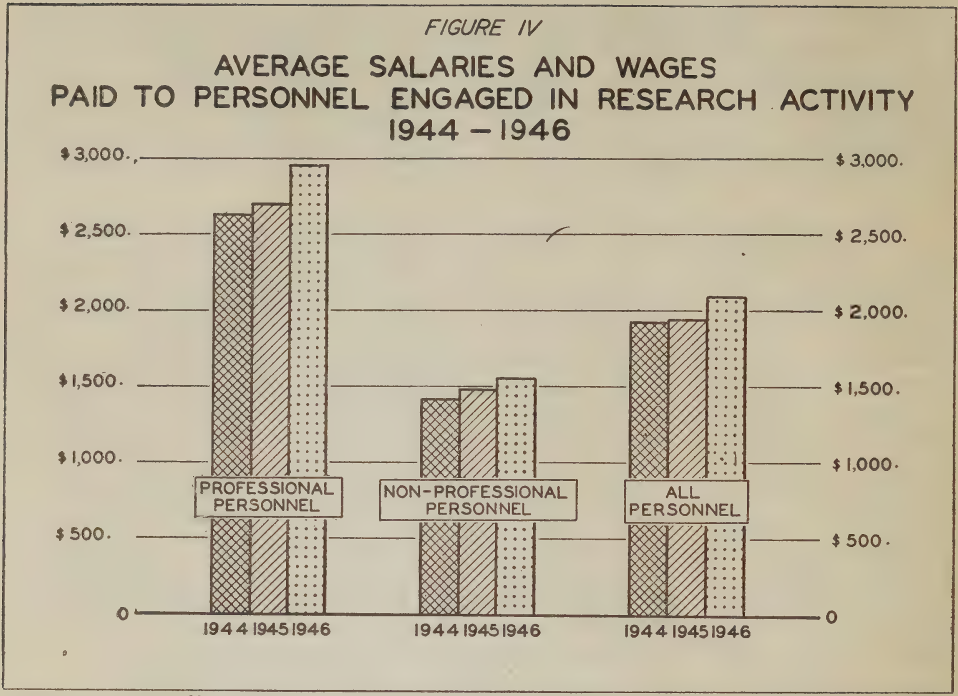
Average annual earnings for professional personnel were around $2,700 in 1945, with but little variation within the various types of scientific activity (see Summary Table 7 and Figure V). However, salaries and wages of non-professional personnel were considerably lower, amounting to little more than half of those paid to professional personnel, due in part to the fact that many of the non-professional staff are young people just out of school, or college students working between terms. In 1945 the average annual earnings for both professional and non-professional persons engaged in scientific work was slightly lower than the $2,000 mark, but there are indications of an improvement in the earning situation as the 1946 average is likely to exceed the 1945 level by about 5 per cent. An even greater improvement is expected for professional personnel employed in research whose salaries appear to have gone up in the last year by about 10 per cent, from $2,708 to $2,960 (see Table 3 in Section III and Figure IV). Compared with average earnings of all civil servants, persons engaged in scientific work are doing a little better than the average. In the fiscal year ending March 31, 1946, the average income of a Federal civil servant was put at about $1,600 as compared with approximately $2,000 for persons engaged in scientific activity (1).

(1) The average yearly salary for civil servants for the fiscal year 1945-46 was arrived at by dividing total salaries and wages paid in that year by the monthly average number of employees on Dominion Government payroll. (See *Summary Statistics of the Civil Service of Canada*, fiscal year ending March 31, 1946, Dominion Bureau of Statistics, Ottawa, 1946).

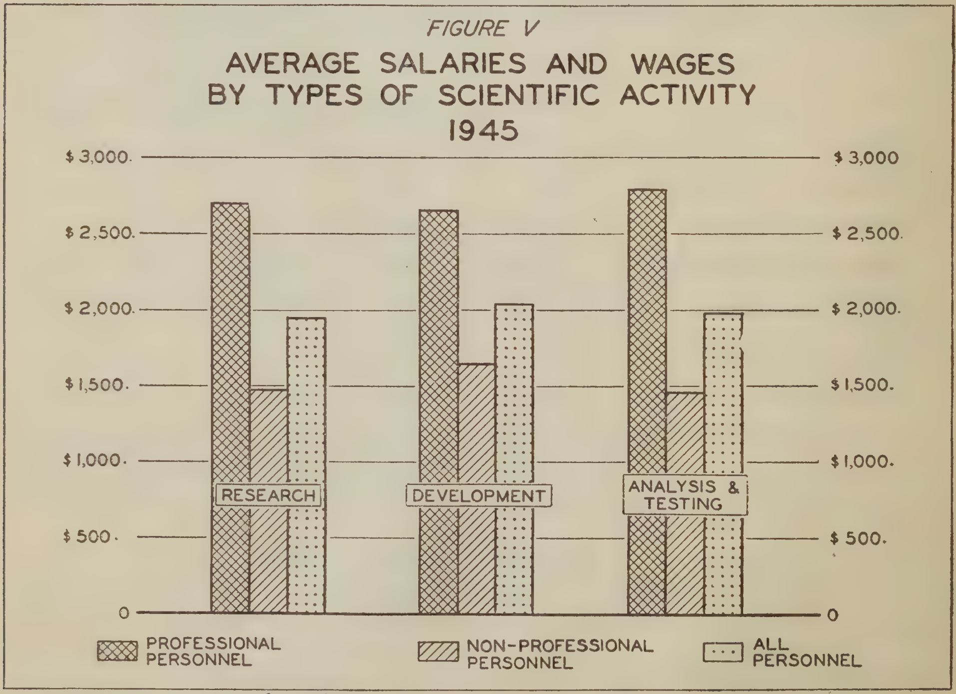
SUMMARY TABLE 7.—EMPLOYMENT AND EARNINGS IN RESEARCH AND SCIENTIFIC ACTIVITY BY DOMINION GOVERNMENT, 1945(1)

Item	Research	Development	Research and development	Analysis and testing	Total scientific activity
1. Employment: (man-years)					
Professional personnel	1,068	443	1,511	352	1,863
Non-professional personnel	1,742	718	2,460	553	3,013
Total personnel	2,810	1,161	3,971	905	4,876
2. Annual earnings: ($000's)					
Professional personnel	2,892	1,182	4,074	983	5,057
Non-professional personnel	2,584	1,193	3,777	812	4,589
Total personnel	5,476	2,375	7,851	1,795	9,646
3. Average annual earnings: (dollars)					
Professional personnel	2,708	2,668	2,696	2,789	2,714
Non-professional personnel	1,483	1,663	1,536	1,467	1,523
Total personnel	1,949	2,047	1,977	1,982	1,978

(1) Fiscal year ending March 31, 1946.



SOURCE: SEE TABLE 3 (SECT. III) ECONOMIC RESEARCH BRANCH, DEPARTMENT OF RECONSTRUCTION & SUPPLY



SOURCE: SEE SUMMARY TABLE 7 (SECT. II) ECONOMIC RESEARCH BRANCH, DEPARTMENT OF RECONSTRUCTION & SUPPLY

In the fiscal year 1945-46 about one-quarter of all expenditures for scientific work went into salaries and wages, while the remaining three-quarters included capital outlay and operating expenses. This ratio was caused in part by the heavy outlay for equipment and other capital goods required in military development work, and is not representative of scientific expenditures in all the departments. For example during the same period, salaries and wages accounted for nearly 80 per cent of total expenditures on scientific work carried out by the Department of Agriculture, while the proportion for Fisheries and Mines and Resources was 50 per cent in each case. For 1946-47 it is anticipated that salaries and wages will represent over one-third of all expenditures for scientific activities undertaken by the Dominion Government.

As emphasized previously, expenditures for research and related scientific activities, and the direct employment provided by these expenditures, is only one way of measuring the significance of such work. By far the more important aspects are the creative results of scientific activity, and their effects on the prosperity and well-being of the citizens of this country. The measurement of these effects, if it can be made possible, remains a task for the future.

SECTION III.

TABULAR MATERIAL

1. Expenditures for Research and Scientific Activity, Dominion Government, by Types, 1938-1946.
2. Expenditures for Research and Development Relating to Natural Resources, Dominion Government, 1938-1946.
3. Employment and Earnings of Personnel Engaged in Research Work, Dominion Government, 1944-1946.
4. Employment and Earnings of Personnel Engaged in Development Work, Dominion Government, 1944-1946.
5. Employment and Earnings of Personnel Engaged in Research and Development Work, Dominion Government, 1944-1946.
6. Employment and Earnings of Personnel Engaged in Analysis and Testing, Dominion Government, 1944-1946.
7. Employment and Earnings of Personnel Engaged in Scientific Activity, Dominion Government, 1944-1946.

TABLE 1

EXPENDITURES FOR RESEARCH AND SCIENTIFIC ACTIVITY, DOMINION GOVERNMENT, BY TYPES, 1938-1946(1)

(thousands of dollars)

Year	Military					Non-military					Military and Non-military				
	Research	Development	Research and development	Analysis and testing	Total scientific activity	Research	Development	Research and development	Analysis and testing	Total scientific activity	Research	Development	Research and development	Analysis and testing	Total scientific activity
1938	112	381	493	157	650	3,858	536	4,394	930	5,324	3,970	917	4,887	1,087	5,974
1939	359	721	1,080	333	1,413	4,147	571	4,718	1,002	5,720	4,506	1,292	5,798	1,335	7,133
1940	1,078	1,064	2,142	711	2,853	3,634	444	4,078	1,075	5,153	4,712	1,508	6,220	1,786	8,006
1941	2,030	1,630	3,660	1,550	5,210	3,479	499	3,978	921	4,899	5,509	2,129	7,638	2,471	10,109
1942	3,079	4,378	7,457	2,083	9,540	3,466	420	3,886	1,063	4,949	6,545	4,798	11,343	3,146	14,489
1943	4,383	7,005	11,388	2,800	14,188	3,763	1,126	4,889	1,062	5,951	8,146	8,131	16,277	3,862	20,139
1944	5,548	11,795	17,343	3,006	20,349	4,370	1,368	5,738	1,115	6,853	9,918	13,163	23,081	4,121	27,202
1945	4,510	22,223	26,733	2,174	28,907	6,320	1,460	7,780	1,249	9,029	10,830	23,683	34,513	3,423	37,936
1946	3,489	13,726	17,215	1,502	18,717	10,276	2,462	12,738	2,488	15,226	13,765	16,188	29,953	3,990	33,943

(1) Fiscal years (corresponding most nearly to calendar years indicated).

TABLE 2

NON-MILITARY EXPENDITURES FOR RESEARCH AND DEVELOPMENT RELATING TO NATURAL RESOURCES, DOMINION GOVERNMENT, 1938-1946(1)

(thousands of dollars)

Type	1938	1939	1940	1941	1942	1943	1944	1945	1946
Agriculture	2,375	2,581	2,074	2,100	2,074	2,282	2,715	3,114	4,441
Fisheries	242	241	230	221	217	236	349	513	740
Mining	645	550	417	436	487	1,224	1,453	1,214	1,753
Forestry	299	284	222	204	186	167	185	286	899
Other	122	122	120	111	105	112	107	121	146
Total	3,683	3,778	3,063	3,072	3,069	4,021	4,809	5,248	7,979

(1) Fiscal years (corresponding most nearly to calendar years indicated).

TABLE 3

EMPLOYMENT AND EARNINGS OF PERSONNEL ENGAGED IN RESEARCH WORK, DOMINION GOVERNMENT, 1944-1946(1)

Year	Professional Personnel			Non-professional Personnel			Total		
	Number employed (man-years)	Salaries $'000	Average salary $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $
1944	1,020.1	2,685	2,632	1,413.1	2,020	1,429	2,433.2	4,705	1,934
1945	1,067.9	2,892	2,708	1,742.1	2,584	1,483	2,810.0	5,476	1,949
1946(2)	1,316.9	3,898	2,960	2,111.4	3,271	1,550	3,428.3	7,169	2,091

(1) Fiscal years (corresponding most nearly to calendar years indicated).
(2) Excluding Defence Research.

TABLE 4

EMPLOYMENT AND EARNINGS OF PERSONNEL ENGAGED IN DEVELOPMENT WORK, DOMINION GOVERNMENT, 1944-1946(1)

Year	Professional Personnel			Non-professional Personnel			Total		
	Number employed (man-years)	Salaries $'000	Average salary $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $
1944	592.9	1,577	2,660	696.1	1,116	1,603	1,289.0	2,693	2,089
1945	443.0	1,182	2,668	717.5	1,193	1,663	1,160.5	2,375	2,047
1946(2)	658.4	1,522	2,312	805.3	1,402	1,741	1,463.7	2,924	1,998

(1) Fiscal years (corresponding most nearly to calendar years indicated).
(2) Excluding Defence Research.

TABLE 5

EMPLOYMENT AND EARNINGS OF PERSONNEL ENGAGED IN RESEARCH AND DEVELOPMENT WORK,

DOMINION GOVERNMENT, 1944-1946[1]

Year	Professional Personnel			Non-professional Personnel			Total		
	Number employed (man-years)	Salaries $'000	Average salary $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $
1944	1,613.0	4,262	2,642	2,109.2	3,136	1,487	3,722.2	7,398	1,988
1945	1,510.9	4,074	2,696	2,459.6	3,777	1,536	3,970.5	7,851	1,977
1946[2]	1,975.3	5,420	2,744	2,916.7	4,673	1,602	4,892.0	10,093	2,063

(1) Fiscal years (corresponding most nearly to calendar years indicated);
(2) Excluding Defence Research.

TABLE 6

EMPLOYMENT AND EARNINGS OF PERSONNEL ENGAGED IN ANALYSIS AND TESTING, DOMINION GOVERNMENT, 1944-1946(1)

Year	Professional Personnel			Non-professional Personnel			Total		
	Number employed (man-years)	Salaries $'000	Average salary $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $
1944	407.5	1,110	2,724	590.7	903	1,529	998.2	2,013	2,017
1945	352.4	983	2,789	553.4	812	1,467	905.8	1,795	1,982
1946(2)	393.7	1,071	2,719	672.8	1,072	1,593	1,066.5	2,143	2,009

(1) Fiscal years (corresponding most nearly to calendar years indicated).
(2) Excluding Defence Research.

TABLE 7

EMPLOYMENT AND EARNINGS OF PERSONNEL ENGAGED IN SCIENTIFIC ACTIVITY,

DOMINION GOVERNMENT, 1944-1946(1)

Year	Professional Personnel			Non-professional Personnel			Total		
	Number employed (man-years)	Salaries $'000	Average salary $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $	Number employed (man-years)	Salaries and wages $'000	Average remuneration $
1944.................	2,020.5	5,372	2,659	2,699.9	4,039	1,496	4,720.4	9,411	1,994
1945.................	1,863.3	5,057	2,714	3,013.0	4,589	1,523	4,876.3	9,646	1,978
1946(2)..............	2,369.0	6,491	2,740	3,589.5	5,745	1,601	5,958.5	12,236	2,054

(1) Fiscal years (corresponding most nearly to calendar years indicated).
(2) Excluding Defence Research.

APPENDIX

Dominion Government Research and Scientific Activity in the Physical and Natural Sciences

During World War II military research played a significant part in the scientific activity of the Dominion Government in the natural and physical sciences, with most Federal departments doing some research work serving war purposes. Naval Services initiated their own research program, working in co-operation with National Research Council on the study of problems relating to naval weapons and equipment, including radar and electronics. The expanded research programs of the Army and Air Force covered a wide field including chemical warfare, operational research, communications, vehicle development. The National Research Council acted as co-ordinating agent and the greater portion of the activities of the Council was directed toward research for military purposes. The Department of Reconstruction (formerly Munitions) and Supply was responsible for certain capital expenditures for military research and development purposes and, in addition, carried out some development work through the Army Engineering Design Branch and Signals Production Branch. Some research and experimental work was also carried on by certain Crown companies reporting to the Minister of Reconstruction (formerly Munitions) and Supply. (1) In addition, other departments such as Mines and Resources, Agriculture, Transport, and National Health and Welfare, were engaged in scientific activities to meet the military requirements of Canada.

With the return of peace the research facilities of the Dominion Government are again reverting to peacetime uses, with activities expanded beyond the pre-war level. Scientific work for the conservation, development and fuller utilization of natural resources is carried out by the Departments of Agriculture and Mines and Resources, by the Fisheries Research Board of Canada, and to some extent by the National Research Council. The Council is also responsible for discovering new, and improving known, technical processes, and for the utilization of the waste products of industry. Research in the fields of radio communication, aeronautical engineering and meteorology, is undertaken by the Department of Transport. The construction of Federal public works requires a certain amount of scientific work in the laboratories of the Department of Public Works. Research and other related scientific activities in nutrition, industrial hygiene, food and drugs, are carried out by the Department of National Health and Welfare. (For a detailed statement of the types of scientific activity undertaken by the various Federal Government departments as of December 31, 1946, see Schedule B).

The current research program of the Federal Government is designed to assist, encourage and stimulate economic development in Canada.(2) For example, work has been started on research to improve the quality and methods of constructing buildings, particularly houses, through more efficient use of existing materials and the development of new materials and techniques. Another instance is the use of molded plywood techniques developed during the war years in connection with aircraft production for the construction of boats, furniture, artificial limbs, and other peacetime products. The application of this new technique aims at providing commodities of improved design produced with greater economy in the use of materials and labour. Research in radar which

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(1) Research Enterprises Limited, Turbo Research Limited, Federal Aircraft Limited, National Railway Munitions Limited, Small Arms Limited, Polymer Corporation Limited.

(2) For a statement on Government policy relating to research, see *White Paper on Employment and Income, with Special Reference to the Initial Period of Reconstruction*, Ottawa, 1945, pp 17-18, and *Proposals of the Government of Canada*, Dominion-Provincial Conference on Reconstruction, Ottawa, August, 1945, p. 24

played such an important part in military operations is being continued for peacetime uses, mainly as an aid to air and sea navigation. In particular, improved equipment has been developed such as a light-weight radio distance indicator designed to give pilots the distance from fixed beacon stations. This instrument is now being installed on T.C.A. aircraft on a "user trial" basis. Another development that promises to yield valuable economies is the use of infra-red apparatus to detect faulty joints in power lines. First experiments in this field were successful, and if commercially exploited it will mean not only a reduction in maintenance costs of power lines but will reduce the number of interruptions to production operations from breaks in power lines due to faulty joints.

Some wartime research brought new knowledge, the application of which was postponed until peace was restored. For instance, in the search for a source of the ingredients of synthetic rubber, new resins produced from wheat mash were discovered that may have great significance for the manufacture of paints and lacquers. These examples illustrate the great stimulus to industrial development that may be derived from a large and well-integrated research program.

SCHEDULE B.—LIST OF DOMINION GOVERNMENT RESEARCH AND SCIENTIFIC ACTIVITIES IN THE PHYSICAL AND NATURAL SCIENCES, AS OF DECEMBER 31, 1946.

Item No.	Department	Branch	Field of Scientific Activity
1	Agriculture	(a) Science Service	(i) Research and experimental studies relating to animal diseases (ii) Research in the field of dairying, food microbiology, soil microbiology and general agricultural bacteriology (iii) Research in the study and control of diseases affecting agricultural and horticultural crops and forest trees (iv) Investigation in soils and fertilizers, animal nutrition and research on vitamins and physiological chemistry, plant chemistry and foods (v) Research in the field of taxonomy, ecology, biological control and various problems involved in the control of insects of economic importance
		(b) Experimental Farms	(i) Animal husbandry (ii) Scientific beekeeping (iii) Research in cereals (iv) Flax fibre research (v) Field husbandry (vi) Forage plants (vii) Horticulture (viii) Poultry husbandry (ix) Tobacco
		(c) Production Service	(i) Chemicals and micro-analysis of seeds, fertilizers, and pest control products, and vitamin assay of animal foods (ii) Research into all fields of seed testing (iii) Studying all information available through cumulative performance records of cattle, poultry and swine—to determine genetical makeup of various strains and families (iv) Application of the above information to the commercial herds of the country (v) Use of biological agents for diagnosis, prevention and eradication of animal diseases (vi) Ante-mortem inspection of meat food animals, and post-mortem inspection of animal carcasses
		(d) Marketing Service	(i) Home canning and freezing (ii) Methods of cooking Canadian foods (iii) Handling — storage — refrigeration and temperature control of agricultural products in railroad and ocean transport (iv) Processing and manufacturing methods of agricultural products (v) Packing and packaging methods (vi) Testing of agricultural products for grade standards

Item No.	Department	Branch	Field of Scientific Activity
2	Mines and Resources	(a) Mines and Geology	(i) Ore dressing and extractive metallurgy (ii) Physical metallurgy (iii) Utilization of industrial minerals (iv) Fuel technology (v) Development of improved ceramic products (vi) Development of acceptance tests for permissible explosives (vii) Geological and geophysical surveys (viii) Research in topographical mapping (ix) Research and ethnological studies in anthropology and archaeology (x) Studies of fauna and flora in Canada
		(b) Lands, Parks and Forests	(i) Forest regeneration (ii) Tree breeding (iii) Forest growth and yield (iv) Forest site classification (v) Cultural practices (vi) Forest mensuration (vii) Forest influences (viii) Fire hazard research and fibre control planning (ix) Fire protection equipment research (x) Aerial photography technique (xi) Pulp and paper (xii) Wood preservation (xiii) Wood chemistry (xiv) Wood technology (xv) Timber pathology (xvi) Timber mechanics (xvii) Lumber seasoning (xviii) General wood utilization (xix) Development of scientific forest working plans (xx) Wildlife management (xxi) Ornithology (xxii) Mammalogy (xxiii) Limnology (xxiv) Ecology
		(c) Surveys and Engineering	(i) Astronomy of position and its application to the determination of accurate time (ii) Study of the sun's radiation and its influence on terrestrial conditions (iii) Research into the structure of the sidereal universe, including the determination of the constitution, radial velocities, and magnitudes of stars through observation and the study of stellar and nebular spectra (iv) Terrestrial magnetism as applied to surveying, and nautical and aerial navigation (v) Seismology and seismic surveying and its application to prospecting and geological investigations (vi) Gravimetric studies of the varying densities of the earth's crust, particularly as applied to rock formations (vii) Investigation into the varying values of atmospheric refraction (viii) Research into highway construction methods and highway materials, and their best utilization in Canada

Item No.	Department	Branch	Field of Scientific Activity
2	Mines and Resources (con't)	(c) Surveys and Engineering (con't)	(ix) Mathematical research to determine the accurate solution of long geodetic lines and to investigate the efficient transfer of geodetic data from one spheroid of reference to another (x) Trans-polar navigation research and development of map projections suitable to aerial navigation (xi) Analysis and study of geodetic field results to determine the size and shape of the earth (xii) Tests of the increased efficiency of lenses of surveying instruments due to fluoriding (xiii) Investigation of behaviour of precise surveying instruments and proposed changes of design to improve their performance and accuracy (xiv) Development of hydrographic survey instruments and methods (xv) Methods of plotting maps from trimetrogon photos and surveys
3	Public Works	(a) Physical Laboratories	(i) Research into, and testing and analysis of, building materials (ii) Soil mechanics and foundations
		(b) Chemical Laboratory	(i) Analysis and testing in connection with protective coatings (ii) Analysis and testing of lubricants and detergents (iii) Inorganic and analytical chemistry
4	Transport	(a) Air Services (1) Radio	(i) Research in methods of investigating measurement and suppression of interference from electrical equipment (ii) Participation in N.R.C. development of radio aids to air navigation (iii) Propagation measurements in connection with interference of broadcasting stations, and development of equipment for use therewith (iv) Participation in N.R.C. operational research in marine radar
		(2) Civil Aviation	(i) Investigation of new aircraft designs for compliance with domestic and international airworthiness requirements
		(3) Meteorological	(i) Investigation into the liquid water content of clouds (ii) Investigation into improved elements for hygrographic instruments (iii) Research and investigation into the three-dimensional structure of the atmosphere (iv) Meteorological aspects of chemical warfare (v) Investigation and study of vertical motion in the atmosphere (vi) Research into the anomalous propagation of radar waves (vii) Solar radiation (viii) Research into upper air conditions

Item No.	Department	Branch	Field of Scientific Activity
4	Transport (con't)	(a) Air Services (con't) (4) Construction	(i) Investigation and analysis of the load carrying capacity of flexible runway pavements and the development of curves and formulae for the design of flexible pavements
		(b) General Engineering	(i) Analysis of hydraulic problems dealing with carrying capacity of channels, roughness coefficients, regulation of flows and levels
5	National Research Council	(a) Division of Applied Biology	(i) Industrial uses for agricultural products (ii) Industrial fermentations (iii) Starch and cellulose chemistry (iv) Oil and fat chemistry (v) Food bacteriology and chemistry (vi) Refrigerating engineering (vii) Plant physiology and biochemistry (viii) Biometrics
		(b) Division of Chemistry (1) Fundamental	(i) Inorganic (ii) Organic (iii) Physical
		(2) Applied	(i) Chemical engineering (ii) Corrosion (iii) Industrial organic (iv) Paints (v) Colloids (vi) Plastics (vii) Leather (viii) Rubber (ix) Textiles (x) Laundry and dry cleaning (xi) Explosives testing
		(c) Division of Mechanical Engineering	(i) Aerodynamics (ii) Aircraft power plants and gas turbines (iii) Liquid fuels and lubricants for power units (iv) Aircraft structures (v) Low temperature operation of aircraft (vi) Hydrodynamics and hydraulics (vii) Mechanical engineering (viii) Fire hazard testing (ix) Artificial limb development (x) Design of building elements for mass production of housing
		(d) Division of Physics and Electrical Engineering (1) Physics	(i) Acoustics (ii) Electrical measurements (iii) General physics (iv) Heat (v) Metrology (vi) Optics (vii) X-rays, radio activity, structure and strength of matter

Item No.	Department	Branch	Field of Scientific Activity
5	National Research Council (con't)	(d) Division of Physics and Electrical Engineering (con't) (2) Electrical Engineering and Radio	(i) Electrical engineering and industrial electronics (ii) Radio communication (iii) Radar and direction finding (iv) Propagation and antenna design
		(e) Division of Medical Research	(i) Co-ordination of, and financial assistance to, medical research
		(f) Division of Atomic Energy	(i) Chalk River Laboratory (ii) Chalk River Pile and Pilot Plant
		(g) Division of Information Services	(i) Library (ii) Publications (iii) Liaison Offices (iv) Technical Information
		(h) Other Activities	(i) 42 Associate Committees for correlation and promotion of research (ii) Research scholarships (iii) Grants in aid for research
6	Reconstruction (formerly Munitions) and Supply	Crown Companies (1) Eldorado Mining & Refining Ltd.	(i) Plant control in production of radium
		(2) Polymer Corporation Ltd.	(i) Research, development and plant control in connection with production of synthetic rubber and related products
		(3) Canadian Arsenals Ltd.	(i) Development of facilities and plant control for the production of ordnance and ammunition
7	National Health and Welfare	(a) Industrial Hygiene	(i) Health and welfare of industrial workers
		(b) Laboratory of Hygiene	(i) Toxins, serums, vaccines, toxoids (ii) Investigation of standards of vaccines for virus diseases (iii) Assistance to provinces in standardization of diagnostic procedures
		(c) Nutrition Services	(i) Research on the state of nutrition of the Canadian people
		(d) Food and Drugs	(i) Analysis of foods and drugs for adulteration (ii) Preparation of standards for foods and drugs (iii) Development of methods for analysis of foods and drugs (iv) Investigation of claims for physiological and pharmaceutical properties of foods and drugs (v) Investigation of medical devices
8	Fisheries	(a) Fisheries Research Board of Canada	(i) Research for development, conservation and regulation of fisheries (ii) Research for improvement of processing, packaging and preservation of fish products and development of new processing technique

Item No.	Department	Branch	Field of Scientific Activity
9	National Defence	(a) Defence Research	(i) Research and development for the improvement of service equipment and material; correlation of these activities between the armed services, and in relation to other government departments and to the civilian scientific community
		(b) Naval Services	(i) Operational research (ii) Acoustic and magnetic research for underwater warfare (iii) Communications and radar (iv) Lifesaving equipment (v) Harbour protection (vi) Ordnance (vii) Clothing, camouflage and general stores
		(c) Army	(i) Operational research (ii) Armaments (iii) Electronic and intercommunication equipment (iv) Vehicle, engineering and mechanical equipment (v) Gas, flame, smoke and biological warfare (vi) Technical and general stores
		(d) Air Force	(i) Aircraft (ii) Power plants (iii) Aerodromes (iv) Ground handling facilities (v) Mechanical transport (vi) Marine craft (vii) Electronic, photographic, instrument, armament, personnel and safety equipment and scientific testing of same for use in the R.C.A.F. (viii) Aviation medicine and dietetics